THE NRDL DYNAMIC MODEL FOR FALLOUT FROM LAND-SURFACE NUCLEAR BURSTS

Research and Development Technical Report USNRDL-TR-410
S-FO11-05-12

5 April 1960

by

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Effects of Atomic Weapons

Technical Objective
AW-5c

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where for the size class μ_1 to μ_2, $\phi_1 = \log \mu_1$, $\phi_2 = \log \mu_2$, $\phi = \log \mu$, $\overline{\phi} = \overline{\log \mu} = 2.053$ (the average value of $\log \mu$), and $\sigma = 0.732$. This equation was derived from Figure 1, which shows for each particle diameter (in microns) plotted vertically on a logarithmic scale, the percentage of activity associated with all particles greater than that size plotted horizontally on a probit scale. The straight-line plot means that the radioactivity has a normal distribution with respect to the logarithm of the particle diameter. The data points in Figure 1, derived from measurements made at JANGLE-Underground [Anderson, 1959, p. 10], is for Nevada soil which possesses properties similar to soils commonly found throughout the world. How well the data of Figure 1 hold for surface bursts occurring over different soils and varying over a wide range of yields is unknown. For most siliceous soils, the sparse data available indicate that for close-in fallout the fraction of radioactivity in a given size range is roughly constant regardless of yield. However, the size-radioactivity distribution for coral is markedly different from that for siliceous soil. For surface bursts in the Pacific, in which the soil consists mostly of coral, an analysis of Operation REDWING data by Ksanda of NRDL [private communication] indicates that the size-radioactivity distribution can be represented by Equation 16, with $\overline{\phi} = 2.209$ and $\sigma = 0.424$.

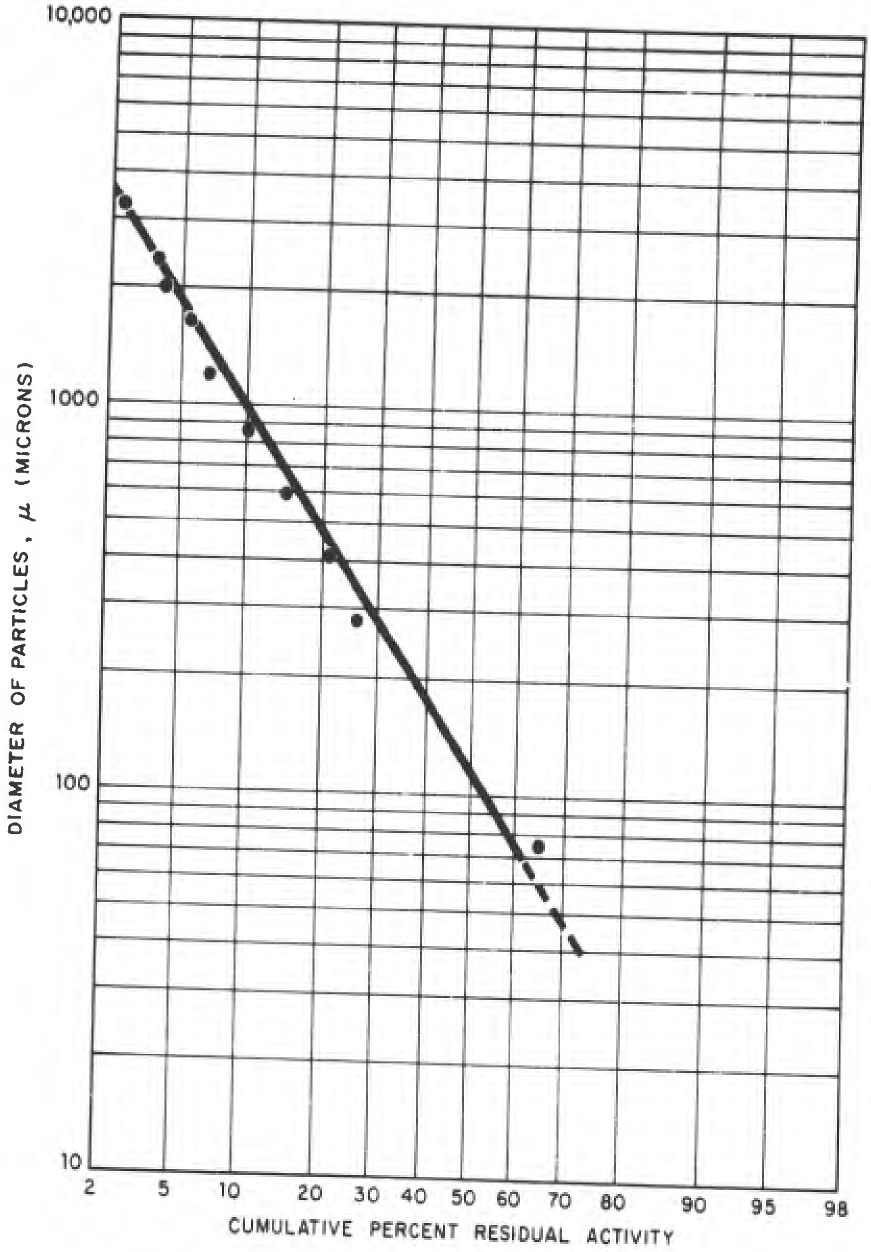

Fig. 1 Cumulative Percent of Residual Activity in All Particles >μ for J-U

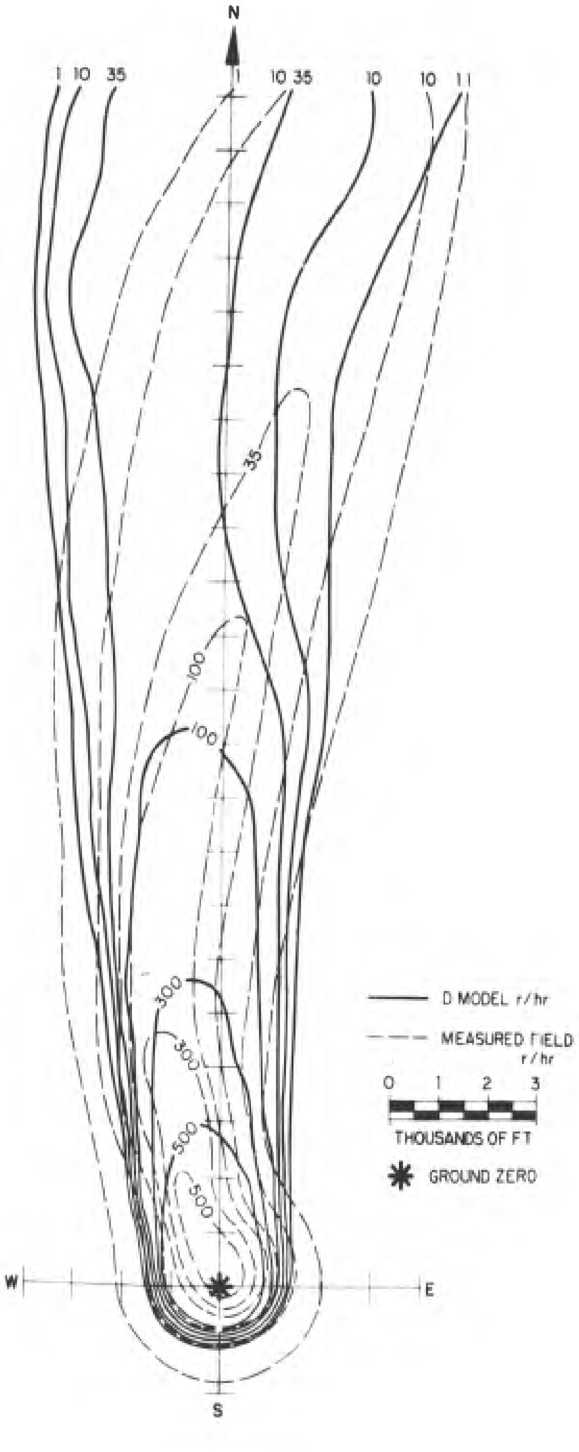

Fig. 2 D-model Dose-rate Pattern Computation for J-S at H+1 Hour

were made. The measured pattern (M pattern) shown for comparison should not be accepted as being a completely accurate representation of the dose-rate field at H+1 hr. Although it is believed to be the most accurate pattern available, it still represents the modified fallout pattern resulting from the attempt to reconcile the disagreements among three different research groups and to complete the contours for the patterns [Laurino and Poppoff]. The JANGLE dose-rate data are based primarily on readings taken with standard field ratemeters (AN/PDR-18, AN/PDR-18A, AN/PDR-18B, TIB, and CDV 710). It has been found [Work] that errors as high as 50 per cent exist in these data, even when the instruments are carefully calibrated and handled. These errors result from uncertainties due to energy dependence in the instrument, variation in instrument position with respect to the observer, and variation in orientation of instrument.

Referring to Figure 2, the overall agreement between the two patterns is very good for the axes, widths, and the configuration of the contours around GZ. In Table 2 the agreement is very good with respect to the location of the maximum dose rates, and the maximum downwind extents of the 100-r/hr, 300-r/hr, and 500-r/hr contours. The agreement is not very good for the magnitudes of the maximum dose rates and the areas enclosed by the contours. The difference between the axes at several miles from GZ probably is due mainly to the distance variation in wind direction. The marked difference shown between the upwind extents of the 1-r/hr contours may reveal the result of ignoring the edge effect of the disks in the D model (Section 3); that is, the "shine" from the intense fallout gradient near GZ may have resulted in readings on instruments situated beyond the fallout zone. The M value for the crater is estimated to be 7500 r/hr; this is much higher than the D value of 1282 r/hr. Probably this difference occurs because the D model does not take into account any particles greater than 10,000 microns (Table 1). Since the J-S fireball was very close to the ground at start of fallout, undoubtedly heavier particles (rocks) became contaminated and fell back into the crater.

Table 2-- Comparison of M and D pattern attributes for J-S

Pattern	Maximum dose rate		Maximum contour distance from GZ (ft)			Contour area (sq mi)		
	Value (r/hr)	Distance from GZ (ft)	500 r/hr	300 r/hr	100 r/hr	500 r/hr	300 r/hr	100 r/hr
M	540	900	2200	4900	12,500	0.05	0.15	0.55
D	1450	500	3050	5800	10,500	0.21	0.43	0.96

JANGLE-Underground-- The D-model dose rates in r/hr at H+1 hr were computed for J-U for 580 evenly-spaced locations; and the fallout pattern was constructed. The D-model input data for J-U were exactly the same as J-S except for the winds. In Figure 3 the agreement between the D and M patterns is quite good for the axes, and for the configuration of the contours of value 100-r/hr and greater. Referring to Table 3, the agreement is very good for the location of the maximum dose rates and the maximum downwind extents and areas enclosed by the closed contours. The agreement is not good for the widths, configurations of contours around GZ, and the magnitudes of the maximum dose rates.

Overall, the agreement between the D and M pattern is good. With regard to the width of the M pattern, the dose-rate measurements for J-U were made after a time interval after detonation sufficiently long to allow redistribution of some of the radioactive fallout by the surface winds. The M pattern is probably broader than the D pattern around GZ because of the minor base surge for J-U (not accounted for in the D model) which surrounded GZ and extended outward several thousands of feet. Also, the M 1-r/hr contour may have been broader because of the "shine" from near GZ. An M value of 6000 r/hr is estimated for the crater's dose rate; this value (like J-S) is much higher than the D value of 1656 r/hr.

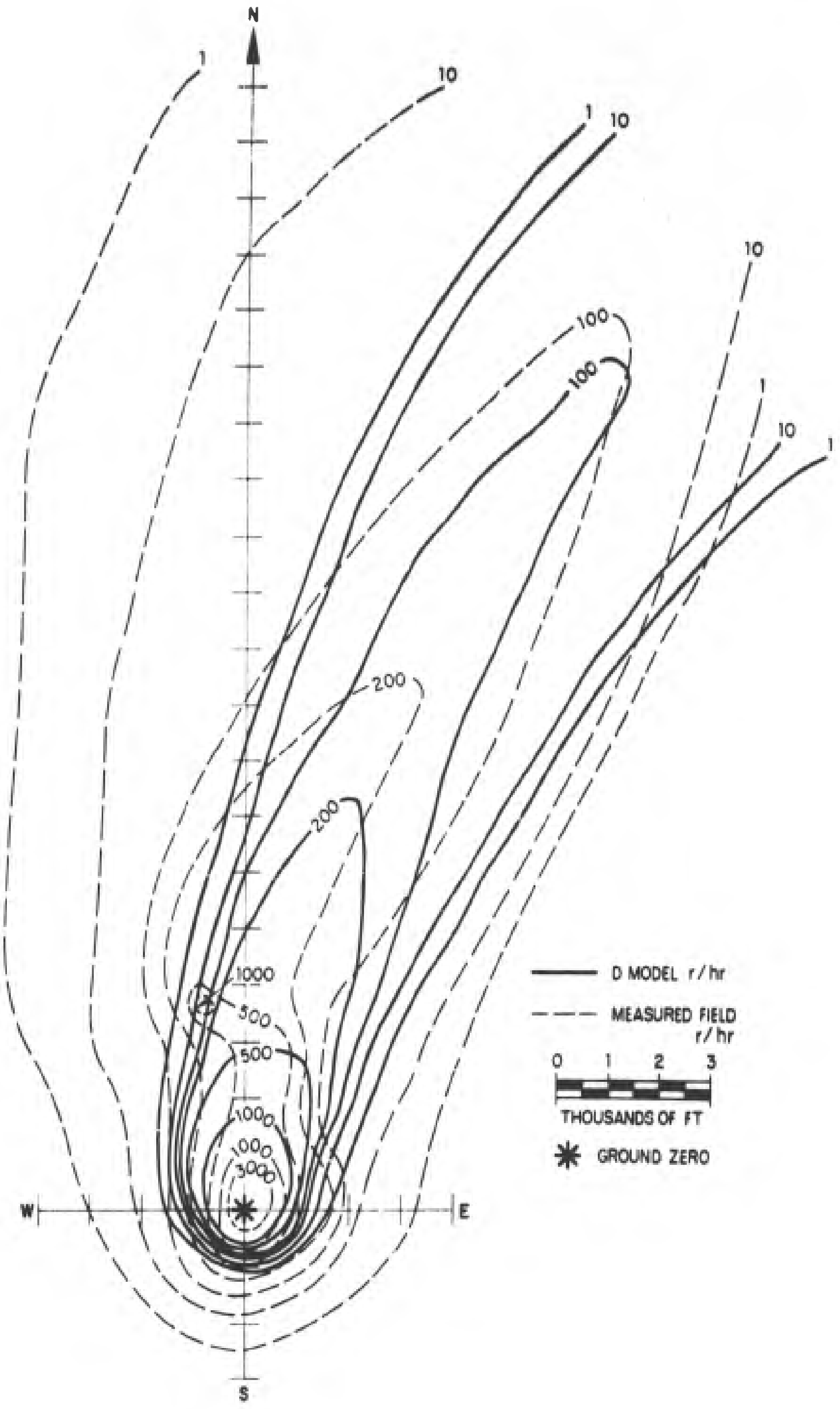

Fig. 3 D-model Dose-rate Pattern Computation for J-U at H+1 Hour

Table 3--Comparison of M and D pattern attributes for J-U

Pattern	Maximum dose rate		Maximum contour distance from GZ (ft)				Contour area (sq mi)			
	Value	Distance from GZ (ft)	1000 r/hr	500 r/hr	200 r/hr	100 r/hr	1000 r/hr	500 r/hr	200 r/hr	100 r/hr
M	3400	930	1250	3500	10,000	17,200	0.08	0.23	0.87	2.26
D	1864	500	1700	3000	7,650	16,900	0.11	0.24	0.60	1.42

A method has been developed [Anderson, 1958] to compute fallout particle-size distributions. Using this method, size-distribution computations were made with the D model [Anderson, 1959, p. 32] for J-U at ground locations 1 and 2 mi north, where size distributions were measured. Comparisons made between the computed and observed distributions showed that the D model gave consistent results; the computed distributions compared favorably with the measured distributions at both locations.

Other comparisons -- The D-model computer program was checked further by using it to compute an H+1 hr dose rate pattern for an Operation CASTLE land-surface shot of about 100-kt yield [Anderson, 1959, p. 48]. The comparison made with locations having measured data was good. Also, the theory developed in Section 2 was used with minor modifications, by the Naval Ordnance Test Station, China Lake, California, to give a computation of the altitude profile of radioactivity at 15 min after burst for a multi-megaton yield land-surface shot at Operation REDWING [Anderson, 1959, p. 51]. This computation showed excellent agreement with measured data.

5. CONCLUSIONS

As a result of favorable comparisons of the D-model fallout patterns with the observed test patterns for Operation JANGLE, it is concluded that the new theory is sound for fallout computation--at least for contact land-surface and shallow-underground bursts of low yield. Preliminary results indicate that the theory can be used to give successful computations for shots in the moderate-yield and high-yield ranges. The D model, derived from the theory, has been programed for a medium-size computer. Thus, it is now possible to compute for any yield and any wind condition deposit and transit dose rates and doses. Dose-rate patterns can be readily computed for any times after burst, and hence the time changes of the fallout patterns (dose-rate changes at given locations) can be taken into account. In order to compute fallout effects from high-yield bursts, it will be usually necessary to take time and distance variations of the winds into account. In principle, it is easy to do this with the computer, but in practice, it may prove difficult because of the lack of sufficient wind data. The most serious objection to this model is undoubtedly its neglect of the extreme turbulence and toroidal circulation within the rising cloud. These subjects are difficult and do not seem thus far to have been considered by anyone. Also, it does not take into account rain scavenging. Otherwise, it is considered to approach reality in as much detail as experimental data permit.

The D model is undoubtedly the most complex model used to date for fallout computation, yet its increased intricacy has resulted in greater accuracy. It cannot at this time be considered for use in the field since its computations take many hours to make. However, this time delay does not mean that the D model has no immediate operational value. One of the main drawbacks to most fallout models has been the lack of knowledge of the size distribution vs altitude (radioactivity vs altitude) at the time the models start fallout (that is, at the time the visible cloud reaches its maximum altitude). Since the D model can be used to compute these distributions, which vary only with yield, it can help in uncovering useful simplifications necessary for operational computational techniques. Nevertheless, the main applicability of the model is to research and planning problems. Improvements in the model can be expected when additional experimental data become available.

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